Department of Materials Science and Engineering Seminar Series 2025

DEVELOPMENT OF HIGH-PERFORMANCE IRIDIUM-BASED CATALYSTS FOR ACIDIC OXYGEN EVOLUTION REACTION

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Venue: EA-06-04

Abstract

Proton exchange membrane water electrolysis (PEMWE) is a promising technology for green hydrogen production. However, its widespread application is constrained by sluggish oxygen evolution reaction (OER) kinetics, limited catalyst durability and the scarcity of iridium. This seminar develops a mechanism-guided catalyst design strategy to simultaneously enhance OER activity, improve structural stability, and minimize Ir utilization.

First, interfacial Ir–O–Mn electronic coupling is engineered to optimize the conventional adsorbate evolution mechanism (AEM), enabling efficient acidic OER with over 800 h of PEMWE operation. Second, a LaO_xH_y–IrO_z heterostructure introduces a hydroxyl-reservoir-assisted lattice oxygen mechanism (HRA-LOM), facilitating oxygen-vacancy replenishment to mitigate the activity–stability trade-off. The resulting catalyst achieves 1.68 V at 3 A cm^{-2} and over 1000 h of durability. Finally, edge-confined non-bonding oxygen species are engineered in O-IrO_x to enable a sequential redox activation mechanism (SRAM), integrating rapid oxygen redox at low potentials with stabilizing metal redox contributions at elevated potentials. This catalyst delivers 1.72 V at 3 A cm^{-2} with only 0.05 mg_{Ir} cm^{-2} and sustains over 4100 h of operation at Ir loading of 0.4 mg cm^{-2}.

These studies establish a progressive pathway from electronic modulation to reaction-mechanism engineering, providing fundamental insights and practical design principles for efficient, durable, and Ir-efficient PEMWE electrocatalysts.

Biography

Ma Yifan received his Bachalor's degree in New Energy Materials and Devices from Soochow University and his Master's degree in Mechanical Engineering from the National University of Singapore (NUS). He is currently pursuing his Ph.D. degree in the Department of Materials Science and Engineering at NUS under the supervision of Prof. Xue Junmin and Prof. Lu Li. His research focuses on developing high-performance Ir-based acidic oxygen evolution reaction (OER) catalysts and their implementation in proton exchange membrane water electrolyzers (PEMWE).

Please join us!

HOST: Asst Prof Zhu Di